

Discussion Notes from the March 22, 2016 Workshop, “Anchoring and Black Swans: Reconsidering Risk Aversion and the Future of Commercial Space”

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On March 22, 2016, thirteen workshop participants, along with the project researchers (Molly Macauley, James Bennett and Katrina McLaughlin) met at Resources for the Future (RFF) in Washington, DC to discuss a variety of issues associated with perception, management, and policy regarding risks associated with commercial space ventures. Following presentations (included as Document 2) on an overview of the issue, the economics of risk assessment, and how risks have been approached in other contexts, workshop participants provided feedback and discussion.

The workshop was held under Chatham House rules, that is, that statements during the workshop could be quoted but not attributed to any participant. Consequently, this set of discussion notes refers to “attendees” rather than any participant by name.

The conversation was wide-reaching and touched upon many of the themes discussed in presentations on risk assessment employing “the value of statistical life” (VSL) idea, and surveys of public attitudes regarding space risks. The comments are presented below as they arose during discussion. Although there are some thematic groupings, we have left them in chronological order to maintain continuity of different points between speakers. We have included section headers for ease of reading, but the headings are not definitive. Comments generally fell within the categories of space “exceptionalism” (that the public views space risk differently and more severely than other risks), risk communication by NASA, how to apply economic “willingness to pay/willingness to accept” (WTP/WTa) frameworks to commercial spaceflight, and anchoring, that is public reference points for forming risk attitudes.

Economic tools and anchoring

One attendee noted some key characteristics of a WTA model, including: the setting is outside of what the public could provide for themselves, that is, government intervention is required. Emphasis was placed on the fact that it is the public’s WTA risk that the government is acting upon and that there is a question whether government ever can or should continue an activity the public deems too risky. However, ascertaining the public’s WTA risk may be difficult if there is not full information on the risks.

One attendee noted that psychological anchoring has not always been borne out in practice. Although Challenger anchored expectations that fatalities could disrupt space-flight development for a significant amount of time, or even end the nascent private industry, those expectations were not borne out in reality. Another participant, however, pointed

out that the fatalities that have occurred so far have been test pilots, not passengers, and so it is yet to be seen what the first passenger fatality may do to the industry.

A tangential conversation occurred about how to capture the benefits as well as the costs and risks of spaceflight. One attendee illustrated the problem of how to express the return on investment (ROI) for NASA with the MRSA vaccine. MRSA research on the shuttle was especially beneficial because the viruses are more virulent in orbit. Being able to study them in space moved scientific research much closer to a vaccine for a disease that has more fatalities than AIDS and high costs and years of life lost. For a cost comparison, the attendee noted that the shuttle program is \$5 billion annually and the MRSA vaccine saves close to \$19 billion annually.

This attendee stressed that current communication strategies do not articulate this value of human spaceflight for medical research. The attendee further stressed that human spaceflight is better suited for research than robotic spaceflight, using the example of the Mars robotic mission. The attendee said that the research a robot does in one year, a human could do in about four days, due to the inability of robots to correct when things go wrong.

One attendee noted that budget pressures may contribute to anchoring experiences. The attendee gave the example that at the times of both the Challenger and Columbia accidents, NASA was experiencing political pressure to have a successful, timely shuttle mission. In the case of Columbia, although some technical design features had been flagged, there was a sense that the mission was "too hot to go" to allow reexamining these features and delaying the mission. The speaker noted that mistakes encountered during the space shuttle program arose not from human spaceflight but from technicalities of the test vehicle. Design features of the shuttles are themselves anchoring mechanisms. The question, then, is how to "un-anchor" something, whether it is a psychological belief or a result of sunk costs in research and development.

The question of how to un-anchor was taken up by another attendee. One response given was experiences that give people a new anchor, saying bad experiences don't go away but you can give people something else to look at. The attendee also noted bureaucracies tendency to self-deceive, noting that prior to Challenger there were only two statisticians employed at NASA working on systemic risk. The burden of knowledge that comes from analysis is a result of the system and its particular psychology and anchors. This attendee noted that it may be much harder to "push the button knowing that there's a 3.1% chance" of a serious accident or loss of life.

Attendees continued their comments on organizational aspects of anchoring by pointing to what they claimed were organizational learning and unlearning between Challenger and Columbia. A more rigorous approach to probabilistic risk assessment (PRA) and economic analysis produced a burden of knowledge upon decisionmakers, in that some would prefer to avoid knowing detailed risk assessments. After NASA said that it was ready to return to flight, it had to go to international partners and the administration. Presidential advisors and staff were appalled at the risks presented to them, saying "no one ever told us"

before that NASA knew there was a significant risk number and still launched. One attendee claimed that it was a Presidential level decision to return to flight, despite the advice from everyone around him. However, the almost self-deception prior to Challenger was replaced by the use of better tools; this is one way in which system evolved.

The attendee continued their remarks by saying that independent of risks being better analyzed and disclosed now, NASA does not take the risks it used to because we are no longer in the Cold War and the perception of space is different. They then pointed to a study by Tversky and Kahneman, that people are reluctant to take losses as opposed to making gains. PRA was developed for a bounded problem, the nuclear industry, and as such can be applied to known and bounded systems, which the shuttle is. An attendee speculated that PRA may be better applied during return to flight than early days. The use of stochastic methods for both risk and cost assessment that started in the 2000s makes sense because NASA gets beat up a lot in cost. A joint cost risk schedule assessment and cost distribution can counter some of this criticism.

The PRA development was very incremental; it got a little better and a little more accepted over time. This attendee stated that now "we may have gone too far on what this number means," noting that the cost analysis is accurate only 20% of the time. There has to be sophistication on how you use the PRA: it's not a number you put in an Excel sheet that goes up to the Hill for a budget. It's a relative not an absolute number, an ordinal not cardinal number. What actually moves the anchor is experience. The danger of getting too lost in analysis is that this it can deviate from actual experience. Taking risk is one thing, but knowing risk is different.

One attendee followed these remarks by stating that we are really dealing with uncertainty, not risk. Another attendee responded to these remarks by stating that having a knowledgeable President making an informed decision is naive. Staff has axes to grind, and NASA has a bureaucratic bias to maintain its infrastructure. The attendee advised to not "hang your hat on people being fully knowledgeable," instead saying the key hook was reusability.

One attendee commented that different decisions will need different levels of approval, noting that the question of flying cargo versus flying a US astronaut are different. They further noted that the number of partners or participants involved changes the manner of the decision, using the analogy of if one were travelling individually or for a family reunion. When more people are involved, you are more likely to travel to a safe and/or convenient location, whereas if you're travelling individually you can take a higher level of risk. The attendee argued that space tourists have control over how much risk they take, and that anchors then are personal and not societal, which we can already see in the private sector. In the government, the number of people with veto power is very high, which may be appropriate for the public sector.

Eventually the market will make the decision on what levels of risk are appropriate. But, the attendee noted, we're two generations from that. Today NASA is setting the safety of these vehicles and is dictating what the commercial spaceflight industry is going to be for

the next twenty years. The attendee noted that NASA was not involved in this sector for private spaceflight but to get astronauts back to ISS and is "spending an incredible amount."

They continued by noting that every mode of transportation has accidents (7000 on bicycles last year), but that some of the reasons that space is seen as exceptional—technological superiority and US exceptionalism—is why Congress funds it and why we place such a high premium on life in space. They noted that the US no longer has the same geopolitical and Apollo context. Once we answer the question of why we do human spaceflight, we will be able to answer the question on what levels of risk are acceptable. At one time the space program wanted to de-orbit the International Space Station (ISS), but remained committed after hearing responses from international partners. They closed by stating that space exceptionalism is a huge anchor.

Another attendee picked up on the theme of a new context for space in two generations time. Asking who are the new protagonists and antagonists in two generations and beyond will shift the perception of risk. Another attendee asked a clarifying question, whether human and vehicle generations are synonymous, which was answered as yes, especially for hardware, and placed at about 20 years.

An attendee commented that the workforces that will be flying in public and private contexts are different, and that there is generally a different risk posture in the private market. Those in the private market are generally going to be particular millionaires and billionaires doing exploratory missions, analogous to expeditions to discover the Nile, not the public writ large. It is this particular population that is going to be using these vehicles in the next generation. The attendee continued by noting that all early explorers of Mt. Everest were joint public/private expeditions, with more funding coming from private than public sources (about 60/70% private, according to the attendee). They continued by stating that the mission to get astronauts to ISS requires success, but that it is preferable to have private infrastructure in place for other people to reach ISS, noting that the public component has a government mission here, while Everest did not.

Measuring the benefits of spaceflight

One attendee noted that the current economy and geopolitical context introduces new ROI arguments, in which spaceflight is not about national prestige but about concrete social benefits. Another attendee noted, however, that you can't predict medical or social benefits, which makes articulating the opportunity cost of not having an extra astronaut difficult. Another attendee said this might be thought of as the shadow price of the astronaut, which was a concept they were more comfortable with than the ROI argument, since if you lack both geopolitical and economic rationale at least you know other partners are also struggling with their own shadow price of an astronaut. They commented that China and the US are the only countries that can put a shadow price on an astronaut, and China is still involved in spaceflight for old arguments (e.g., prestige).

Another attendee countered that a lot of continued spaceflight endeavors by NASA is "for the jobs programs," both within NASA and the general aerospace industry. They argued that NASA should let the private players go off and make mistakes on their own, rather than trying to compete with the private spaceflight industry.

One attendee asked whether there had been a departure from the risk-taking behaviors seen in the 19th and 20th century that led to exploration and the willingness to take risk. Another attendee responded that this hasn't stopped, but argued that in order to undertake these risky explorations, there has to be some exterior motive beyond just doing the unknown. They argued that there was always some exterior motivation (e.g., looking for the Northwest Passage for commerce), and that these explorations had a practical set of objectives and were not just done for fun. Nothing has changed. They argued 20th century exploration was built around a similar set of objectives, and that space exploration has not had that commercial aspect. They saw robotics as the one exception of being a field with a motivating commercial aspect, but noted that it is human spaceflight that the traditional excitement has been concentrated around. They closed by saying that commercial activities have not followed in the space arena, and that they are elemental for long-lasting development.

An attendee followed up on this comment by stating that a focus just on "exploration" must be expanded to "exploration, development, and settlement." They further stated that the US cannot get out of an Apollo mindset. If we don't know why we're exploring then we're not going to do it right.

Another attendee commented that they think the 2010 NASA policy on exploration of Mars and asteroids is an incredible short-term anchor, whose language is freighted with expectations that flow downstream in a way that people don't fully appreciate. They continued that the analogy for where the spaceflight industry is right now is the transition from airmail to commercial air flight, with private actors are now investing their own money in what was traditionally a limited government enterprise. The commenter thought the analogy with northern expeditions (e.g. Arctic expeditions searching for a Northwest Passage) was not as strong. They closed by noting that astronauts can opt out, but cannot opt in if NASA says a situation is too risky.

Historical analogues

An attendee noted that risk does not stop when an astronaut returns home, but that medical effects, for example, eyesight, bone loss and radiation-related cancer risk, continue after the end of a mission. NASA acknowledges this and views risk not just as the mission, but as the mission and beyond. Similar cases can be found in some of the analogies to a certain extent. Participants in volcanology can get long-term effects from breathing sulfur, and some medical effects of deep water diving can manifest over a longer time period. They provided the case of nuclear weapons workers in Tennessee as a good example, where the government surveys people until they die and pays their medical bills if they get cancer due to certain impacts. The thinking in both this case and space is the government position of "If we expose them to the risk, we take responsibility for it."

One attendee asked if the analogies being offered had examples of informed consent within them. With regard to private spaceflight, do operators have legal liability for micro gravity health effects? Another attendee answered that it is not clear, but that "everyone will sign away their rights to sue for everything," and that participants will probably get second party insurance. They also noted the law created federal preemption. Other participants would later note that liability waivers did not stop lawsuits in other industries.

An attendee elaborated on the analogy of airmail, saying that over the course of eight years when the service began, thirty pilots were lost. They stated that there was at that time more tolerance within government for loss of life, and noted that government pilots had a much higher rate of loss than commercial pilots. This was partly due to the fact that commercial pilots generally had more years of experience. They further reported that when the Army took over the airmail service in 1934, the fatality rate increased with nineteen pilots lost in the space of three months. Even with federal action (Airmail Act) during the early 1930s, the loss rate within the industry was comparable to losses experienced when the Postal Service was flying with federal employees in the 1920s. The attendee ended their remarks by noting that this period of sector growth amid high loss occurred with only one presidential commission (1934), suggesting less oversight and alarm at the level of risk being taken.

Another attendee followed this series of remarks by saying that there is a need for good empirical research on the change in risk tolerance in culture, not just rates of change over average lifespans but analyses of rapid onset of loss life examples. They hypothesized that different expectations (i.e., anchoring) and language (and how it influences expectations) may have a large role. For instance, there is a different connotation around exploration versus development; I don't expect any people to die when I develop a condo.

Agency risk communication and informed consent

An attendee noted that the anchoring bias within spaceflight erodes trust among the public. The acceptance of risk will be different in different sectors, and each will have its own reactions: regulatory reactions, public and political reactions, legal reactions, technical reactions, etc. These can result in FAA regulations and market regulation. They noted, as an example of another high risk activity that has a different anchor, that Everest kills 1 in 62, yet people continue to pay \$20,000 per climb for what is perceived as a highly risky activity.

They noted that the role of language around expectations was on display during the Virgin Galactic incident of October 2014, in which the FAA came out very clearly as stating "we did our job; no one on the ground died." The attendee wondered if really there was zero responsibility politically, but noted that there was no Congressional hearing on it (although there was an NTSB and public hearing), which could be seen as a trust-building exercise between the agencies and the public. Another attendee followed up on this comment by elaborating that the cultivation of a testing culture within FAA had a big part in the overall positive response, emphasizing that FAA had been very clear in the run up to call it a test flight. That is, it was not a licensed activity, and after the incident OSHA was first on

the ground. The attendee commented, "It worked the way it was supposed to work." Proper communications prior to, during, and after an incident can do a lot to lower the reaction to risk or channel it, and make it such that there is a narrative that agency responsibilities were carried out.

One attendee argued that Congress treats NASA differently with regards to oversight, risk tolerance and budgeting. Another attendee argued that it was not a matter of public money, but the sense that a NASA astronaut is a national treasure. Another attendee followed this statement by pointing out that it was a circular argument to say that if astronauts are such national treasures that we can't risk them for a hazardous activity like human spaceflight, then the very thing that makes them a national treasure (human spaceflight) is void.

Another attendee followed up on this thread by pointing out that there are important distinctions between a NASA fatality and a private test pilot fatality. A NASA fatality takes place in the public eye, has a cost aspect due to its public funding, and demands transparency between the agency and Congress (and the public). They noted that despite this, NASA still does experimental high risk activities. They continued their remarks by saying that NASA settled with the family of the Columbia astronauts for "inordinate" amounts of money, an option that test pilots don't have. The role of family in cases of NASA fatalities is important, and they noted differences in the response of Challenger and Columbia families. Challenger fatalities were memorialized, but the families of the Columbia fatalities had to make an effort to make the deaths mean something. Astronaut families are able to have an impact on the broader public conscience and reform, while test pilot families do not.

An attendee followed these remarks by commenting that they perceived a lack of transparency in government space missions. They asked why NASA institutionally plays down the fact that something is a test flight and inherently risky? Or why do they sometimes refer to a shuttle as a 'space truck'? Perhaps this is because people do not want NASA to do very risky activities with the public's money, which begs the question of whether NASA is doing something important enough to be worth the risk.

They continued their comments by summarizing an aerospace safety advisory panel meeting with private spaceflight companies in Houston. There was an issue where the space shuttle program had elected to take more risk, and the private actors were working with NASA to see why and asked if it was going to communicate this higher risk posture. NASA simply responded, "We think it's in the best interest of the program." The attendee thought this a highly conservative and guarded explanation, which may reflect current exploration activities relating to Mars and a tremendous anxiety over the upcoming transition across Presidential administrations. The speaker could understand the emotion, but said it doesn't serve NASA well and all in all was a "terrible answer."

Another attendee asked for what point is human life worth risking at all, saying "we need to be playing for higher stakes." They recalled past efforts to decrease the probability of loss of crew from 1 in 100 to 1 in 1000, which led to escape systems and different shuttle designs. They argued that if NASA plays for higher stakes, it needs to be transparent about

what stakes are too high. It's an order magnitude increase of 1 in 100 (which they said most people think of as "horrific") to 1 in 1000. They argued that NASA has completely lost the thread of the idea that loss of crew risk could be tolerated at 1 in 1000. They recalled that the astronaut office wrote an internal memo putting forth the risk acceptance of 1 in 1000, but it was not agency policy and the memo eventually got shuffled off and lost. They returned again to the need to establish what level of risk is too much, arguing that 1 in 1000 is too expensive and that NASA would not be flying if risk threshold was held here. They said that there is a feeling, but no supporting analysis, that 1 in 1000 was too expensive. They noted that the "constellation lock code" fail rate was 1 in 270.

An attendee pointed out here that there is a difference between risk and risk perception, and gave the example of terrorism, in which risk perception is much higher among the US public than the actual level of risk. Another attendee followed this quip by saying that in the case of terrorism, every day is treated as a black swan, and DHS is viewed very differently from a risk perspective. The mission is paramount, and costs did not matter. Biomonitoring on the DC subway scan every 12 hours, with \$5.4 billion spent on mass weapons for a terrorist attack that will likely not happen. The speaker acknowledged the different risk perception among the public regarding terrorism, saying "every American is terrified of terrorism, but not of drinking Flint's water."

An attendee noted that the WTP framework is usually applied as an individual's willingness to pay to reduce risk to themselves, not others. Here, the question seems to be how much is an individual willing to pay to reduce risk to someone else, and empirically they have no idea how one would get data on that, given that VSL estimates are extremely noisy even within the traditional framework. They also noted that a particular VSL may not be tied to the agency eventually using it, for example a VSL estimate used by DOT may come from a study of construction workers on tall buildings.

An attendee revisited the early conversation of needing to move from exploration to development by stating that development is hard for bureaucracies. They said that it's not just what an agency is willing to spend but when you're willing to spend it. If an agency spends 15% of its budget, then there is already a pre-ordained life cycle of that system. Another attendee also added that the way development money is spent is crucial.

Another attendee stated that informed consent is not a magic bullet, and does not make an industry or operator immune from regulation and liability. Informed consent has appeal as a voluntary transaction that the industry has developed, but they still may have as many problems as before. The commenter then asked, if informed consent is not a be-all end-all, what is the agency's responsibility?

Public support and communication

An attendee said that it was correct to think that the public is more risk tolerant than government agencies, and that there is evidence for this in the space policy context but looking at public grieving and recovery in the immediate aftermath of Challenger and Columbia. The public is sympathetic, and views space legacy as part of our national identity

and is not dissuaded by loss of life incidents but say that it continues to be important to the public. Polling on the issue taken two to three years later after the return to flight showed continued acceptance of risk, although that acceptance did go down a little bit.

An attendee noted that the political narrative in which public support occurs is important. Tacit, passive public support doesn't translate into a benefit for NASA, but someone can gain immediate benefit from "beating up on" agency officials. The attendee commented that the Bush administration's 2006 space policy is largely the same as what's in Obama's space policy, yet widely different reactions to the two shows that the narrative and image of the administration plays a large role. They also note that the time sequencing up to an event matters, and the actors involved matters on whether it will play into a particular narrative, particularly whether there will be an intense partisan reaction.

They continued by saying that polling results are important because they can help to offset some of the damage around anchoring by showing that public support can remain high even during extreme incidents. They noted that public tolerance of risk and support is high right after shuttle fatalities. They speculated that risk aversion may not come from the public, but from particular political and corporate circumstances. They noted a corporation, North American Aviation, ceased to exist after Apollo 1 although the space shuttle program continued.

They thought that articulating some of these background circumstances will make it clearer where the anchored expectations surrounding the space shuttle program might come from. They pointed to this as one benefit of the current study. They also thought that there had been successful efforts by NASA to shift the anchor through pretty concerted action, which another attendee responded to by saying that old anchors can still be seen at play when there are hearings and when there is not transparency on the part of the agency.

To elaborate, they said that the public communication over loss of life by NASA and others would be a great data point. The reaction to a loss of life incident is crucial, and managing communications is important not just in the lead-up to activities. They stated that in the FOIA requests after Columbia, the internal bias at NASA became towards openness. The agency would redact for personal stuff but otherwise did not use the exceptions it could have. The intent of this flood of material going out the door was a hint that NASA wasn't trying to find or hide anything, and to pre-empt an investigations. For publicly funded systems, they saw this as the right thing to do. An attendee responded to this comment by stating that when they saw the flood of information, they assumed NASA was just trying to buy the public. They then stated that the expected loss of life ratio through time, and how it has been communicated, would be highly useful even if only a couple of data points were available.

An attendee offered another example of government management of risk perceptions, that of public support for wartime operations. A RAND study of the Vietnam War summarized that Johnson missed the strategic military context because he wanted to keep casualties down in an effort to not decrease public support for the war. But public support actually decreased due to a public perception that there was not a plan to win the war. Another

attendee followed up on this comment by saying that public communications is key, saying they remembered Walter Cronkite announcing that the war was unwinnable and the effect it had.

They also pointed to the relationship between NASA PR and classified material. They then stated that one makes a lot of assumptions in order to say that the benefits of space exploration outweigh the risks to astronauts. When people describe what they think “benefits of space exploration” means, the answer is filled with the ambiguity inherent in space exploration. They stated that the space community needs to bring the public along with us. For commercial spaceflight, this needs to involve saying that these are ultrahazardous vehicles, and there is a real risk you will die on this vehicle.

After one attendee stated that NASA had more people emailing them after the release of the movie *The Martian* than any public relations work NASA has ever put out itself, another attendee responded by saying that public perceptions are shaped by a variety of things, including pop culture, but there’s no way to measure how much it attributes to public perception. They also noted that movies will likely only give happy endings.

An attendee noted that some of the anchoring and public perceptions of NASA were not limited to the US. When the US went to Chile to assist in the miner recovery effort, the Chileans changed their views of the likelihood of mission success drastically when they heard NASA was involved.

Organizational culture and external expectations

An attendee responded to this comment by saying that NASA plays into that perception, and wants to project that expertise that eventually sets it up for failure. They recalled an anecdote that Buzz Aldrin wanted the Apollo golden legacy memorial to start with the Apollo 1 fire, and incorporate into the agency a narrative that failure was necessary to get to program success. They closed their comment by emphasizing the need for a different risk management approach within NASA, suggesting that something as simple as a safety minute—that says this is how things screw up, here are actions you can take to avoid them—builds risk management into the culture of an organization beyond just bumper stickers and sets forth how professional people deal with risk.

An attendee followed this comment by stating that it is almost impossible to have a conversation about the enormous risk of manned spaceflight, particularly in a commercial crew. The original, primary criticism of commercial manned spaceflight is that it was not going to be safe, but the attendee felt that the conversation had now swung too far the other direction and that there is a message that it is going to be safe. They stressed that this should always be recognized as an inherently risky endeavor, like every mode of transportation.

An attendee commented that it could be easier to say that safety is not the first priority if you have a quantitative target to push for. Going from a point estimate to a stochastic estimate would separate the politics of OMB budget fights from the development of cost estimates. Say that the NASA target is to halve the chance of a loss of crew from 1 in 100 to 1

in 200. If a Congressman then responds that they want a 1 in 500 chance, it would be helpful to have a hypothetical program on hand to be able to describe the cost and time delay. They stressed that this was a lack of communication of good analysis. What was needed was for those involved to be an economist and reveal prices of different risk preferences so that the market can clear.

An attendee pushed back on this line of thought by saying the reality is that NASA has to appeal to the interests of Congress, even if they can be nonsensical. The NASA Administrator has to say that safety is the first priority, but can then follow with "we are not always going to live up to it, here are the challenges we face." But to say anything other than safety, in this political environment, would be suicide.

An attendee commented that politicians hate surprises to the extent that a politician wouldn't like a surprise birthday party. Agencies need to prepare the groundwork for political battles by showing politicians careful analysis and "let them yell about it in prep beforehand." They stated that what gets agencies into trouble is when every message has to be the same. This sets up a brittle situation where one crack can ruin your entire credibility.

An attendee commented that they would like for NASA to be able to take the long view, but they do not see how to start that conversation and are worried that it might just reinforce the existing anchor. They suggested having the chief engineer and technical leadership have responsibility for developing any long term analyses, in the hope that engineering rather than political considerations are the driving factor. Another attendee commented that FAA is "great at sending people underneath," and that it is not always the message that stands at the end.

An attendee noted that the space community is so narrow, that there are no voices that could actually have the credibility to take the conversation of risk anchoring outside of NASA. They argued that the discussion needs to be broadened, since the current 'outside voices' such as RAND are too close with NASA and the spaceflight operators.

An attendee offered a possible talking point for a commercial crew: safety is the first priority, and that's why an exploration period where the industry tries different approaches is so crucial. Speak about safety as a strategic goal that risk-taking will get the industry to eventually achieve. We can see this already, with commercial spaceflight operators like Boeing and SpaceX taking different approaches from each other. The second generation of vehicles and operations will be safer because each can learn from the other's different approaches. The industry can't, however, say that they are going to have different safety postures. Safety always is going to be the first priority; no one can do anything else in a speech.

One attendee commented on the need to get people to understand the tradeoff between cost, schedule, and risk. In order to do this you need analysis and the intellectual capability within the agency to create different scenarios. Since at the end of the day you cannot pay a contractor to have your best interests at heart, you must be able to show those within your agency or that have oversight of your agency a schedule of different options.

Another attendee commented that there is a difference between safety and mission success. They gave an example in which the DOE changed its strategy on radiation doses for PRA, and Congress agreed. The attendee said that this change in risk posture allows an argument for what's reasonable in order to get to mission success, although several attendees disagreed that this sort of behavior could be expected from Congress.

An attendee argued that the way to weather space exceptionalism is through numbers, and re-emphasized the need for analysis that is understandable to the actors involved. Take the example of Virgin Galactic or any commercial spaceflight company trying to figure out how to explain risk to potential space tourist, and how to position themselves against their competitors in the market for space tourism. Clearly the activity is not as controlled as getting on an airliner, but is there a way that they can explain the riskiness of the activity in a wall chart or other number. The listener may not be a statistician, but there is a commercial market aspect to informed consent that these companies are going to be figuring out.

An attendee followed this comment by stating that there has already been within the industry a big fight over how to set standards for risk. It was largely a methodology conversation, with people arguing for different statistical methods to calculate the risk (e.g. presume failure on next flight, what is the percentage, what are the Bayesian priors, etc.). They stated that there were definite schools within the industry, including people who did not want to put out any number since they had a goal and narrative to support. The point of the conversation was to standardize risk analysis communication across the industry, but they couldn't at this time. Another attendee commented that they expect the industry eventually will standardize, otherwise it will be very expensive for all involved.